Asian Journal of Soil Science and Plant Nutrition

Volume 10, Issue 4, Page 1-12, 2024; Article no.AJSSPN.121199
ISSN: 2456-9682

The Effect of Nutrient Seed Priming on Nutrient Concentration and Uptake of Soybean

Ugile S.K. [a*], Kausadikar H.K. [b], Waghmare M.S. [c] and Patil.V.D [b]

[a] Department of Soil Science and Agricultural Chemistry, Collage of Agriculture, Badnapur, VNMKV, Parbhani, 431 402 (M.S.), India.
[b] Department of Soil Science and Agricultural Chemistry, Collage of Agriculture, Parbhani, VNMKV, Parbhani, 431 402 (M.S.), India.
[c] Department of Soil Science and Agricultural Chemistry, Collage of Agriculture, Daharashiv, VNMKV, Parbhani, 431 402 (M.S.), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajsspn/2024/v10i4376

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/121199

Original Research Article

Received: 03/07/2024
Accepted: 05/09/2024
Published: 10/09/2024

ABSTRACT

This study aimed to evaluate the impact of nutrient seed priming on the nutrient concentration and uptake in soybeans' and experiment was carried out two consecutive years at research farm of Oilseed Research Station, Latur under VNMKV, Parbhani, during *kharif*, 2018 and 2019 in randomized block design (RBD) with 12 treatments which were replicated thrice. The soil of experimental field was clayey in texture (*Vertisols*),The treatments comprises T_1: absolute control,T_2: Only RDF,T_3:RDF + Zn@ 3g kg^{-1} seed,T_4 :RDF + B @ 3g kg^{-1} seed,T_5: RDF+ Fe@ 3g kg^{-1} seed.,T_6: RDF + S @ 3g kg^{-1} seed,T_7: RDF + *Z*n+ B each @ 3g/kg^{-1} seed,T_8: RDF + *Z*n+ B +Mo each @ 3g kg^{-1} seed ,T_9:RDF + *Z*n+ B + Mo + Fe each @ 3g kg^{-1} seed **,**T_{10}: RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1} seed ,T_{11}:RDF + *Rhizobium* +PSB each @ 10 ml kg^{-1} seed ,T_{12}: Without RDF

**Corresponding author: Email: skugile@gmail.com;*

***Cite as:** S.K., Ugile, Kausadikar H.K., Waghmare M.S., and Patil. V.D. 2024. "The Effect of Nutrient Seed Priming on Nutrient Concentration and Uptake of Soybean". Asian Journal of Soil Science and Plant Nutrition 10 (4):1-12. https://doi.org/10.9734/ajsspn/2024/v10i4376.*

+ Zn+ B + Mo + Fe + S each @ 3g kg^{-1} seed. The results indicated that the priming of Zn+ B + Mo + Fe+ S each @ 3g kg^{-1} seed along with RDF proved its superiority over rest of treatments, however, Priming with a combination of Zn, B, Mo, Fe, and S along with RDF resulted in a significant increase in nutrient concentration and nutrient uptake of soybean over alone nutrient application and control treatment.

Keywords: Soybean; nutrient; uptake; priming macronutrient.

1. INTRODUCTION

"Soybean *Glycine max* (L.) Merill] is originated in China and introduced in India in recent past.Soybeans is the world's foremost provider of vegetable protein and oil, because it has a wide range of geographical adaptation, unique chemical composition, good nutritional value, functional health benefits and variety of end-uses (food, feed and non-edible). It is called as golden bean or miracle bean and has witnessed phenomenal growth in production, processing and trade in last few years in India and has revolutionized the rural economy and improved socio economic status of the farmers. Soybean improve the soil health and fertility by fixing nitrogen through biological nitrogen fixation in soil which is carried out by symbiotic nitrogen fixing bacteria residing in the root nodule of soybeans" [1]. "India ranks fifth in area and production of soybean after USA, Brazil, Argentina, and China" (FAO, Stat 2012). "In India, area under soybean crop from past four decades has increased appreciably, during 2013-14 the crop was cultivated on 122 lakh ha area with productivity of 779 kg ha^{-1}. Madhya Pradesh is known as soybean bowl of India, contributing 59 per cent of the countries soybean production followed by Maharashtra with 29 per cent contribution and Rajasthan with a 6 per cent contribution".

"One of the major constraints in crop production in Vertisols of Maharashtra is unavailability of macro and micronutrients in appropriate amount to crops.And problem of micronutrient deficiency is becoming more serious due to introduction of high yielding varieties, increasing cropping intensity, use of high analysis fertilizers and limited use of organic manures" [2]. "These are causes for poor productivity of oilseed crops. Hence, it is necessary to adopt the proper micronutrient management practices to increase the productivity of oilseed crops.Normally these nutrients are provided through different methods like, soil application and foliar spray. But these are expensive and sometime plant roots are unable to absorb. So it is necessary to develop alternative method to increase the micronutrients availability. One of such method is "Seed Nutrient priming"Nutrient seed priming is a technique in which seeds are soaked in a mineral nutrient solution with subsequent re-drying to the initial moisture content".

"These of macro and micronutrient enriched seeds (seed priming) has been reported to be a better strategy in overcoming macro and micronutrient. It is one of the physiological methods, which improves seed performance and provide faster and synchronized germination and increase yield and quality improves the crop stand, establishment advances phonological events, and increase yield and micronutrient grain contents. Nutrient seed priming has been shown to enhance the speed of germination and stress tolerance. Treating seeds with micronutrients potentially provides a simple inexpensive method for improving micronutrient plant nutrition" [3]. Seed may be treated with micronutrients either by soaking in nutrient solution of a specific duration (seed priming) with micronutrients. In seed priming, seeds are partially hydrated to allow metabolic events to occur without actual germination and re-dries (near to their original weight) to permits routine handling [4].

2. MATERIALS AND METHODS

2.1 Experimental Site

To investigate the effects of priming soybean seeds with solutions of micronutrients including Zn, B, Fe, S, and Mo, alone and in combination, on their nutrient uptake and concentration, the trial was carried out two consecutive years using Soybean crop (Var. MAUS 162) at research farm of Oilseed Research Station, Latur under VNMKV, Parbhani.

2.2 Experimental Detail

After completion of preparatory tillage operations, the experiment was laid out in randomized block design (RBD) with twelve treatments of micro nutrient priming along with RDF replicated three times as per fixed plan and site. Five micronutrient i.e. Zinc ($ZnSO_4$*)*, Iron ($FeSO_4$*)* Boron (H_3BO_3) Elemental sulphur (S), and Ammonium molybdenum (Mo) were used for priming at a rate of 3g kg^{-1} of seed along with the bio fertilizer *Rhizobium* and *PSB* applied at 10 $mlkg^{-1}$ of seed.

The details of treatments are given below

- $\mathbf{T_1}$:Absolute Control
- $\mathbf{T_2}$: Only RDF
- $\mathbf{T_3}$: RDF + Zn@ 3g kg^{-1} seed
- $\mathbf{T_4}$: RDF + B @ 3g kg^{-1} seed
- $\mathbf{T_5}$: RDF + Fe @ 3g kg^{-1} seed
- $\mathbf{T_6}$: RDF + S @ 3g kg^{-1} seed
- $\mathbf{T_7}$: RDF + *Z*n + Beach @ 3g/kg^{-1} seed
- $\mathbf{T_8}$:RDF + *Z*n + B +Mo each @ 3g kg^{-1} seed
- $\mathbf{T_9}$: RDF+*Z*n+B+Mo+Fe each @ 3g kg^{-1} seed
- $\mathbf{T_{10}}$: RDF + *Z*n + B +Mo +Fe +S each @ 3g kg^{-1} seed
- $\mathbf{T_{11}}$: RDF + *Rhizobium* + *PSB* each @ 10 ml kg^{-1} seed
- $\mathbf{T_{12}}$: Without RDF + *Z*n + B +Mo +Fe each @ 3g kg^{-1} seed

One kilogram of soybean seed for each treatment taken and added 10 to 15 ml of a solution with varying concentrations of micronutrients and micronutrients mixture (nutria priming) was added for the same. The seed were the re-dried with forced air in the shade until they returned to their original weight and moisture content .

Soybean seeds were sown on 24 June 2018 and 30 July 2019 using the dibbling method randomly replicated plot measuring 5.4× 4.5m^2 with row to row spacing 45 cm and plant to plant spacing 5 cm, using a seed rate of 65 kg ha^{-1}. All the plots were fertilized with the recommended dose of NPK (30:60:30 kg ha^{-1}) applied entirely as a basal dose and micronutrients seed priming was performed at the time of sowing. Recommended agronomic practices were followed. The crop was harvested at maturity stage on 03rd October, 2018 and 4th November 2019.

2.3 Methods of Plant and Grain Analysis

Fresh plant samples were collected at various growth stages and grain samples were collected at harvest. The sample were processed according to standard procedures involving of of washing, drying and grinding. A 0.2 g sample of ground material was digested with 5 ml of di-acid mixture (HNO_3:$HClO_4$ in a 9:4 ratio) in a digestion chamber until complete digestion was achieved. The residue was dissolved in double-distilled water and after filtration the final volume was adjusted to 50 ml. Nutrient content in the plant and grain sample was analyzed for the total nitrogen content using the Micro-kjeldahl's method [5], total phosphorus using the vanadomolybdo phosphoric acid yellow colour method spectrophoto-metrically as described by Jackson [6] and total potassium estimated by di-acid extraction using flame photometer as described by Piper [7]. The data collected from these observation were analysed statistically by the procedure outlined by Panse and Sukhatme [8].

3. RESULTS AND DISCUSSION

3.1 Nitrogen Concentration (per cent) in Plant and Grain

The data narrated in Table 1 indicates that, during the years 2018 and 2019 under soybean crop nitrogen concentration in plant, was observed higher in (1.19 and 1.36 per cent) at flowering (1.21 and 1.38 per cent) at pod development and (0.95 and 1.03 per cent) at harvest of soybean with the seed application of *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed along with RDF followed by treatment T_9,T_8 ,T_6, T_7 and which were found to be at par with each other. However, lowest was recorded in absolute control treatment T_1 (0.96 and 0.98 per cent) at flowering (0.90 and 0.98 per cent) at pod development (0.84 and 0.89 per cent) at harvest of soybean for both the years. The pooled mean data revealed that, nitrogen concentration was influenced significantly and highest was observed in treatment T_{10} receiving(1.28, 1.30 and 0.99 per cent) RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed at flowering, pod development and harvest stage of soybean and which were at par with T_9, T_8, T_7,T_6 and followed by treatment T_9 .Whereas, lowest value was noted in absolute control treatment T_1 (0.95, 0.94, 0.86 per cent) respectively. The nitrogen concentration in soybean plant was highest at pod development over flowering and slight decreased up to harvest over both stages of soybean.

Nitrogen concentration in grain of soybean was varied from 4.47 to 6.20 per cent, 4.92 to 5.95 per cent and 4.69 to 6.08 per cent during 2018, 2019 and pooled mean respectively. Highest nitrogen concentration was registered due to application of RDF and micronutrient priming of Zn + B + Mo + Fe+ S each @ 3g kg^{-1}seed (6.20, 5.95 and 6.08 per cent) and followed by T_9, T_3, T_8, T_7, T_6 ,T_5 andT_{11} which were at par each otherduring the year of 2018, 2019 and pooled mean. Lowest value of nitrogen content in grain of soybean at harvest (4.47, 4.92 and 4.69 per cent) was obtained with application T_1 absolute control during both years of experiments and pooled data. From pooled data, "Priming with a combination of Zn, B, Mo, Fe, and S along with RDF resulted in a significant increase (T_{10}) in nutrient uptake, with a 29.63 % increase in nitrogen concentration in the soybean grain compared to the control

These results are in line with Zeidan and Gomaa [9] Suman *et al*. [10] who reported effect of sulphur and phosphorus application N, P and K contents of soybean grown on Vertisol.

3.2 Phosphorus Concentration (per cent) in Plant and Grain

The changes occurred in phosphorus concentration in plant at various growth stages and grain of soybean presented in Table 2. During the years 2018 and 2019 under soybean crop phosphorus concentration in plant, was observed higher with the seed application of T_{10}(0.89 and 0.81 per cent) at flowering (0.92 and 0.82 per cent) at pod development and (0.45 and 0.47 per cent) at harvest of soybean RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed followed by treatment T_9, T_8, T_6, T_7 and which were found to be at par with each other. However lowest was noted in absolute control treatment T_1 (0.45 and 0.44 per cent) at flowering (0.36 and 0.37 per cent) at pod development (0.27 and 0.27 per cent) at harvest of soybean for both the years. The pooled mean data revealed that, phosphorus concentration was influenced significantly and highest was observed in treatment T_{10} (0.85, 0.87 and 0.46 per cent) RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed at flowering, pod development and harvest stage of soybean and followed by treatment T_9, T_8, T_7, T_6, T_4, $T_3$and which were found at par with T_9,T_8 ,T_7,T_3,T_4,T_5.Whereas ,lowest value of phosphorus concentration was recorded in absolute control treatment T_1 (0.45, 0.37and 0.27 per cent) at all growth stags respectively.The phosphorus concentration in soybean plant was highest at pod development over flowering and slightly decreased at harvest over both stages of soybean.

Phosphorus concentration in grain of soybean varied from 0.30 to 0.42 per cent and, 0.31 to 0.51 per cent during 2018 and 2019 respectively, whereas, 0.31 to 0.47 per cent in pooled mean data. During the year 2018, 2019 and pooled data, phosphorus concentration in seed of soybean were observed significantly higher in T_{10} (0.42, 0.51 and 0.47 per cent) Zn + B + Mo + Fe+ S each @ 3g kg^{-1}seed application along with NPK, which were found at par with treatments T_9, T_8, T_7,T_6, T_5 and T_3 during 2018 and 2019 and all treatments except T_1, T_{11} and T_{12} during pooled analysis. Whereas, lowest value was found with T_1 absolute control. However, phosphorus content in grain was increased to the extent of 51.61 per cent due to nutrient priming with RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed as compared to absolute control during pooled analysis.

The current study showed that seed priming with different micronutrient solutions was effective and practical way of improving Zn, Cu, and P contents. Seed-priming improves crop performance by inducing physiological, molecular and biochemical changes [11]. These results are in line with Zeidan and Gomaa [9].

3.3 Potassium Concentration (per cent) in Plant and Grain

The data narrated in Table 3 revealed that, during both yearstreatment T_{10} receiving RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1} seed priming was registered potassium concentration up to extent of (2.22 and 2.12 per centat flowering, 1.42 and 1.35 per centat pod development and 1.20 and 1.22 per centat harvest) of soybean. Whereas, when compared with all treatment potassium concentration found minimum in T_1 absolute control (1.11 and 1.23 at flowering, 0.88 and 0.95at pod development 0.97 and 0.92 at harvest) of soybean during experimental two year respectively. After studied pooled date,significantly highest potassium concentration was registered with treatmentT_{10} receiving RDF + *Z*n+ B + Mo + Fe+ S each @3g kg^{-1} seed (2.17, 139 and 1.21 per cent) and at par with all treatment except T_2, T_1, T_{12}at flowering, pod development and harvest stage of soybean. While,minimum potassium concentration was recorded in T_1absolute control (1.17, 0.91and 0.94 per cent) treatment respectively. The status of potassium concentration showed increased trends up to pod development and after that slightly decreased at maturity of soybean

Table 1. Nitrogen concentration (per cent) in plant and grain of soybean as influenced by macronutrients and priming treatments of micronutrients

Tr.	Nitrogen concentration (per cent)											
	Plant									Grain		
	Flowering stage			Pod development stage			Harvesting stage			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1	0.96	0.93	0.95	0.90	0.98	0.94	0.84	0.89	0.86	4.47	4.92	4.69
T_2	1.05	1.07	1.06	0.91	1.09	1.00	0.82	0.89	0.85	5.66	5.06	5.36
T_3	1.09	1.15	1.12	1.19	1.31	1.25	0.73	0.91	0.82	6.20	5.43	5.81
T_4	0.99	1.07	1.03	1.13	1.15	1.14	0.82	0.93	0.88	5.41	5.23	5.32
T_5	1.11	1.07	1.09	1.21	1.14	1.18	0.83	0.88	0.85	6.03	5.40	5.72
T_6	1.18	1.26	1.22	1.19	1.37	1.28	0.84	0.95	0.90	5.87	5.82	5.85
T_7	1.10	1.32	1.21	1.23	1.28	1.26	0.94	1.00	0.97	6.07	5.74	5.90
T_8	1.16	1.28	1.22	1.12	1.36	1.24	0.93	1.01	0.97	6.18	5.82	6.00
T_9	1.14	1.39	1.26	1.13	1.38	1.25	0.94	1.01	0.98	6.05	5.60	5.83
T_{10}	1.19	1.36	1.28	1.21	1.38	1.30	0.95	1.03	0.99	6.20	5.95	6.08
T_{11}	1.02	1.41	1.21	1.05	1.42	1.24	0.87	0.99	0.93	5.82	5.71	5.77
T_{12}	0.97	1.05	1.01	1.00	1.00	1.00	0.87	0.92	0.90	4.48	5.20	4.84
SE±	0.043	0.058	0.036	0.043	0.069	0.040	0.038	0.036	0.035	0.331	0.119	0.166
CD at5%	0.127	0.170	0.105	0.126	0.201	0.117	0.111	0.105	0.103	0.970	0.350	0.486
GM	1.080	1.198	1.139	1.107	1.239	1.173	0.866	0.950	0.908	5.703	5.491	5.597

Table 2. Phosphorus concentration (per cent) in plant and grain of soybean as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Phosphorus concentration (per cent)											
	Plant									Grain		
	Flowering stage			Pod development stage			Harvesting stage			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1	0.45	0.44	0.45	0.36	0.37	0.37	0.27	0.27	0.27	0.30	0.31	0.31
T_2	0.82	0.68	0.75	0.53	0.60	0.57	0.35	0.33	0.34	0.37	0.38	0.38
T_3	0.89	0.76	0.83	0.84	0.66	0.75	0.38	0.41	0.40	0.41	0.43	0.42
T_4	0.86	0.81	0.83	0.81	0.72	0.77	0.41	0.37	0.39	0.34	0.41	0.38
T_5	0.81	0.77	0.79	0.62	0.68	0.65	0.42	0.36	0.39	0.38	0.39	0.39
T_6	0.81	0.81	0.81	0.86	0.74	0.80	0.33	0.40	0.36	0.42	0.42	0.42
T_7	0.83	0.78	0.80	0.80	0.77	0.79	0.33	0.46	0.40	0.38	0.40	0.39
T_8	0.82	0.80	0.81	0.78	0.86	0.82	0.43	0.43	0.43	0.39	0.45	0.42
T_9	0.85	0.80	0.82	0.82	0.84	0.83	0.38	0.46	0.42	0.40	0.46	0.43
T_{10}	0.89	0.81	0.85	0.92	0.82	0.87	0.45	0.47	0.46	0.42	0.51	0.47
T_{11}	0.87	0.79	0.83	0.67	0.70	0.69	0.38	0.39	0.38	0.34	0.35	0.34
T_{12}	0.65	0.63	0.64	0.56	0.44	0.50	0.34	0.31	0.33	0.35	0.35	0.35
SE±	0.045	0.054	0.043	0.044	0.050	0.049	0.030	0.027	0.025	0.023	0.027	0.035
CD at5%	0.131	0.159	0.127	0.129	0.148	0.143	0.089	0.080	0.072	0.066	0.080	0.102
GM	0.795	0.741	0.768	0.714	0.685	0.700	0.372	0.390	0.381	0.375	0.406	0.390

Table 3. Potassium concentration (per cent) in plant and grain of soybean as influenced by macronutrients and priming treatments of micronutrients

Tr.	Potassium concentration (per cent)											
	Plant									Grain		
	Flowering stage			Pod development stage			Harvesting stage			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1	1.11	1.23	1.17	0.88	0.95	0.91	0.97	0.92	0.94	1.14	1.15	1.14
T_2	1.45	1.83	1.64	0.92	1.03	0.97	1.00	0.98	0.99	1.16	1.19	1.17
T_3	1.86	1.82	1.84	1.41	1.39	1.40	1.05	1.02	1.04	1.19	1.26	1.23
T_4	1.56	1.69	1.62	1.18	1.22	1.20	1.04	0.99	1.01	1.27	1.33	1.30
T_5	1.63	1.78	1.71	1.37	1.34	1.36	1.08	1.04	1.06	1.40	1.43	1.42
T_6	2.21	2.07	2.14	1.48	1.35	1.41	1.20	1.17	1.18	1.39	1.40	1.39
T_7	2.02	2.03	2.02	1.23	1.20	1.21	1.08	1.11	1.10	1.46	1.43	1.44
T_8	2.20	2.04	2.12	1.23	1.24	1.23	1.07	1.13	1.10	1.42	1.50	1.46
T_9	2.07	2.18	2.13	1.37	1.34	1.35	1.12	1.11	1.12	1.41	1.55	1.48
T_{10}	2.22	2.12	2.17	1.42	1.35	1.39	1.20	1.22	1.21	1.49	1.61	1.55
T_{11}	2.06	1.84	1.95	1.24	1.21	1.22	1.06	1.00	1.03	1.45	1.46	1.45
T_{12}	1.68	1.77	1.73	1.11	0.98	1.04	1.03	0.95	0.99	1.16	1.17	1.17
SE±	0.179	0.138	0.119	0.097	0.088	0.074	0.044	0.049	0.038	0.081	0.070	0.070
CD at5%	0.525	0.405	0.348	0.285	0.259	0.217	0.129	0.143	0.112	0.237	0.200	0.206
GM	1.839	1.867	1.853	1.236	1.215	1.225	1.076	1.053	1.064	1.329	1.372	1.351

Potassium concentration in grain of soybean varied from 1.14 to 1.49 per cent, 1.15 to 1.61 per cent and 1.14 to 1.55 per cent during 2018, 2019 and pooled data respectively. Potassium concentration was recorded significantly highest in seed (1.49,1.61 and 1.55 per cent in the treatment T_{10}receiving RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed application and which were found at par with T_9, T_8 ,T_7 ,T_6,T_{11} and T_5.Whereas, lowest value (1.14, 1.15 and 1.14 per cent) was obtained with absolute control in T_1 treatment during 2018, 2019 and pooled means, respectively. Moreover, pooled mean results indicated that, as compared to control treatment 35.96 per cent increase potassium concentration in grain due to nutrient priming with *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed along with recommended dose of fertilizer.

3.4 Nitrogen Uptake (kg ha^{-1})

The data pertaining in Table 4, During the year 2018 nitrogen uptake in grain, plant as well as total at harvest of soybean was recorded higher in treatment T_{10} (130.64, 18.74 and 149.38 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed priming and superior over control and lower nitrogen uptake was observed in absolute control treatment (73.53, 12.92 and 86.45 kg ha^{-1}).In respect of nitrogen uptake in grain, plant and total by soybean T_{10} was found at par with treatments T_9 ,T_8 ,T_6 ,T_5 and T_9 ,T_8 .

During the year 2019, nitrogen uptake in grain, plant and total by soybean was noticed highest in treatment (72.17, 11.43 and 83.60 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed priming. In case of nitrogen uptake in grain and plant by soybean treatment T_{10} was found to be at par with treatment T_6,T_9, $T_8$and T_7 respectively. Whereas, lowest value was observed in absolute control treatment T_1 (43.58, 7.41 and 50.99 g ha^{-1}). However, T_{10} was found superior over rest of the treatments regarding total nitrogen uptake by soybean.

From pooled mean of two years data it is cleared that, nitrogen uptake in grain and plant by soybean crop was influenced significantly highest in treatment T_{10} (101.41, 15.08 and 116.49 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed priming and found superior over remaining treatments. Whereas, lowest nitrogen uptake was noted in absolute control treatment (58.55, 10.17 and 68.72 kg ha^{-1}). In respect of nitrogen uptake in plant by soybean, treatment T_{10} followed by par treatment T_9 and T_8.

The increased uptake of nitrogen might be resulted due to increased dry matter production. These results are in conformity to the finding of Vyas *et al.* [12] in soybean. Our findings are in conformity with the earlier researchers Goiba *et al.* [13], Barangule *et al*. [14] who observed the seed dressing with RDF + Zn EDTA @ 3 g per kg of seed recorded significantly higher N,P, K concentration and higher N, P, K uptake. The higher nitrogen absorption may also be due to stimulatory effect of zinc and boron on nitrogen uptake.

Table 4. Nitrogen uptake (kg ha^{-1}) in soybean at harvest of grain and plant as influenced by macronutrients and priming treatments of micronutrients

Tr.	Nitrogen uptake (kg ha^{-1})								
	2018			2019			Pooled		
	Grain	Plant	Total	Grain	Plant	Total	Grain	Plant	Total
T_1	73.53	12.92	86.45	43.58	7.41	50.99	58.55	10.17	68.72
T_2	100.68	13.76	114.43	47.57	8.13	55.70	74.12	10.94	85.07
T_3	122.59	12.48	135.07	57.19	8.90	66.09	89.89	10.69	100.58
T_4	100.88	13.53	114.41	50.17	8.37	58.55	75.53	10.95	86.48
T_5	116.81	14.71	131.52	58.86	8.31	67.17	87.83	11.51	99.35
T_6	112.52	15.32	127.84	64.37	9.08	73.45	88.44	12.20	100.64
T_7	109.70	15.83	125.53	57.46	10.01	67.47	83.58	12.92	96.50
T_8	121.67	16.88	138.55	62.80	10.88	73.68	92.24	13.88	106.12
T_9	119.01	16.78	135.79	61.60	10.61	72.20	90.30	13.69	103.99
T_{10}	130.64	18.74	149.38	72.17	11.43	83.60	101.41	15.08	116.49
T_{11}	108.87	15.79	124.65	57.55	9.67	67.21	83.21	12.73	95.93
T_{12}	77.50	14.12	91.61	48.72	9.20	57.92	63.11	11.66	74.77
SE±	7.204	0.979	7.448	2.958	0.580	3.008	3.774	0.686	3.229
CD at5%	21.128	2.872	21.844	8.676	1.700	8.822	11.069	2.012	9.469
GM	107.86	15.071	122.937	56.836	9.334	66.170	82.351	12.203	94.554

3.5 Phosphorus Uptake (kg ha^{-1})

The data showed in Table 5,among the different treatments phosphorus uptake in grain, plant and total (grain + plant) of soybean was found significantly highest with treatment (8.92, 9.04 and 17.96 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed priming during the years of experimentation 2018 and it was found to be at par with treatments T_9, T_8, T_6,T_3 in respect of phosphorus uptake grainT_9, T_8andT_8in respect of plant and total uptake by soybeanWhereas, lowest phosphorus uptake value was observed in absolute control treatment T_1 (4.93, 4.05 and 8.98 kg ha^{-1}). However, in case of phosphorus uptake by soybean plant, treatment T_{10} was found at par with T_9, T_8 and T_5 as well as in respect total phosphorus uptake T_{10} was found at par with T_8.

Significantly highest phosphorus uptake in grain, plant and total of soybean was recorded with T_{10} (6.12,5.28 and 11.40 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S @ 3g kg^{-1}each seed during 2019 and was found to be at par with treatments T_9,T_8, T_7 in respect of phosphorus uptake by soybean plant. Whereas, lowest phosphorus uptake value was observed in absolute control treatment T_1 (2.78, 2.30 and 5.08 kg ha^{-1}). However, in case of phosphorus uptake by soybean in grain and total uptake treatment T_{10} was found to be superior rest of the treatments and at par with T_9.

Pooled data of both the years signified, phosphorus uptake in grain, plant and total by soybean crop was influenced significantly maximum in treatment T_{10} (7.52, 7.16 and 14.68 kg ha^{-1}) application of RDF and *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed priming, while minimum phosphorus uptake was noticed in treatment T_1 (3.85, 3.18 and 7.03 kg ha^{-1}) absolute control. In case of phosphorus uptake by soybean grain, treatment T_{10} found best over rest of the treatments.

The higher P uptake may be due to the solubilization of native phosphorus by the micronutrients in addition to applied fertilizers which ultimately resulted in better root growth and increased physiological activity of roots to absorb more phosphorus. This result might be due to synergistic effect of iron with phosphorus increased nutrient uptake will result in higher dry matter production and yield. These findings are in conformity with the result reported by Ravi *et al.* [15], Barangule *et al*. [14] observed seed dressing with RDF + Zn EDTA @ 3 g per kg of seed recorded significantly higher N,P,K concentration and higher N,P,K uptake. The total P uptake increased with increasing levels of P Dubey *et al.* [16].

Table 5. Phosphorus uptake (kg ha^{-1}) in soybean at harvest of grain and plant as influenced by macronutrients and priming treatments of micronutrients

Tr.	Phosphorus uptake (kg ha^{-1})								
	2018			2019			Pooled		
	Grain	Plant	Total	Grain	Plant	Total	Grain	Plant	Total
T_1	4.93	4.05	8.98	2.78	2.30	5.08	3.85	3.18	7.03
T_2	6.59	5.77	12.36	3.62	3.02	6.65	5.11	4.40	9.51
T_3	8.15	6.60	14.75	4.59	4.08	8.67	6.37	5.34	11.71
T_4	6.34	6.78	13.12	4.00	3.35	7.35	5.17	5.07	10.24
T_5	7.37	7.50	14.87	4.28	3.44	7.72	5.83	5.47	11.30
T_6	8.08	6.00	14.08	4.60	3.82	8.42	6.34	4.91	11.25
T_7	6.95	5.56	12.51	3.96	4.57	8.53	5.46	5.06	10.52
T_8	7.69	7.76	15.44	4.87	4.59	9.46	6.28	6.17	12.45
T_9	7.82	6.83	14.66	5.03	4.89	9.92	6.42	5.86	12.29
T_{10}	8.92	9.04	17.96	6.12	5.28	11.40	7.52	7.16	14.68
T_{11}	6.27	6.93	13.21	3.57	3.75	7.31	4.92	5.34	10.26
T_{12}	5.99	5.58	11.58	3.27	3.14	6.41	4.63	4.36	8.99
SE±	0.490	0.681	0.917	0.356	0.363	0.587	0.338	0.430	0.367
CD at 5%	1.436	1.997	2.689	1.043	1.066	1.722	0.991	1.261	1.076
GM	7.093	6.534	13.627	4.224	3.852	8.076	5.658	5.193	10.852

Table 6. Potassium uptake (kg ha^{-1}) in soybean at harvest of grain and plant as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Potassium uptake (kg ha^{-1})								
	2018			2019			Pooled		
	Grain	Plant	Total	Grain	Plant	Total	Grain	Plant	Total
T_1	18.66	15.00	33.66	18.85	7.71	26.56	18.76	11.35	30.11
T_2	20.83	16.35	37.18	21.23	8.99	30.22	21.03	12.67	33.70
T_3	23.53	18.19	41.72	24.83	10.05	34.88	24.18	14.12	38.30
T_4	23.81	16.12	39.93	24.84	8.79	33.63	24.33	12.45	36.78
T_5	27.30	19.16	46.46	27.71	9.89	37.61	27.51	14.52	42.03
T_6	26.64	21.56	48.20	26.83	11.18	38.01	26.73	16.37	43.11
T_7	26.40	18.12	44.52	25.84	10.91	36.75	26.12	14.52	40.64
T_8	27.64	19.32	46.96	29.51	12.04	41.55	28.58	15.68	44.25
T_9	27.70	20.38	48.08	30.42	11.64	42.07	29.06	16.01	45.07
T_{10}	31.58	24.13	55.71	34.34	13.72	48.06	32.96	18.92	51.88
T_{11}	27.15	19.28	46.43	27.38	9.64	37.02	27.27	14.46	41.73
T_{12}	20.13	19.45	39.59	20.19	9.47	29.66	20.16	14.46	34.62
SE±	1.825	1.609	2.523	1.735	0.620	1.991	1.525	0.999	1.952
CD at 5%	5.353	4.720	7.400	5.087	1.819	5.840	4.473	2.930	5.725
GM	25.116	18.920	44.036	25.998	10.336	36.334	25.557	14.628	40.185

3.6 Potassium Uptake (kg ha^{-1})

In the year 2018 (Table 6) highest potassium uptake in grain, plant and total by soybean crop was recorded with application of T_{10} (31.58, 24.13 and 55.71 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S each @ 3g kg^{-1}seed application and found superior over rest of treatment in case of potassium uptake in grain and total uptake by soybean. While minimum potassium uptake was recorded in treatment T_1 (18.66, 15.00 and 33.66 kg ha^{-1}) absolute control. In respect of potassium uptake in plant Treatment T_{10} followed by T_9, T_6 and found at par with each other.

Significantly highest potassium uptake in grain, plant and total by soybean was observed in treatment T_{10} (34.34,13.72 and 48.06 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S @ 3g kg^{-1}each seed priming during 2019 and was found to be at par with treatments T_9in respect of potassium uptake in grain by soybean. Whereas, lowest nitrogen uptake value was observed in absolute control treatment T_1 (18.75, 7.71 and 26.56 kg ha^{-1}). However, in case of potassium uptake in plant and total uptake by soybean, treatment T_{10} was found to be superior rest of the treatments.

The pooled mean of trial years data revealed that, potassium uptake in grain, straw and total by soybean crop was influenced significantly maximum in treatment T_{10} (32.96,18.92 and 51.88 kg ha^{-1}) receiving RDF + *Z*n+ B + Mo + Fe+ S @ 3g kg^{-1}each seed priming and found to be at par with treatment $T_{9,}$ in case of potassium uptake in grain and plant and lowest value of potassium uptake was observed in absolute control T_1 (18.76,11.35and 30.11kg ha^{-1}).

The increase in uptake of nutrients may be due to the nutrient priming with micronutrients. These results are in accordance with the findings of Sale and Nazirkar [17] who reported that micronutrient application had significant effect on nutrient uptake of soybean. Increased potassium uptake might be due to better plant growth leading to higher uptake of nutrients and further on the stimulatory effect of B and Zn in absorption of potassium. Barangule *et al*. [14] reported that seed dressing with RDF + Zn EDTA @ 3 g per kg of seed recorded significantly higher N,P, K concentration and higher N, P, K uptake.

4. CONCLUSION

In conclusion seed nutrient priming is an attractive and straightforward alternative for nutrient supplementation. The study found that priming soybean seeds with micronutrient mixture *Z*n + B + Mo + Fe and S at a rate of 3g per kg of seed combined with the recommended NPK dose (30:60:30 per kg ha) significantly enhanced nutrient content and uptake. Our findings suggest that nutrient seed priming could be a cost-effective strategy to enhance the nutrient profile of soybeans, potentially improving crop yield and nutritional value."

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Arshad Javaid and Nasir M. Growth, nodulation and yield response of soybean to biofertilizer and organic manures P. Journal. Bot. 2010;42(2):863-871.
2. Anonymous. Total oilseed area, production and productivity in India. Directorate of Economics and Statistics; 2010.
3. Farooq M, Wahid A, Siddique KHM. Micronutrient application through seed treatments A review. Journal of Soil Science and Plant Nutrition. 2012;12 (1):125-142.
4. Bradford KJ. Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. Hort Sci. 1986;21:1105-1112.
5. AOAC. Official methods of analysis of the chemicals, 10th Edn. Washington, D.C; 1965.
6. Jackson ML .Soil chemical analysis, advanced course. Madison, Wisconsin, U.S.A; 1973.
7. Piper CS. Soil and plant analysis, Asian Reprint Hans publishers, Bombay. 1966;368.
8. Panse VG, Sukhatme PK. Statistical methods for agriculture workers, (IV Edn.) ICAR, New Delhi. 1985;145-156.
9. Zeidan MS, Mohamed MF, Gomaa. Effect of foliar fertilization of Fe, Mn and Zn on wheat yield and quality in low sandy soils

fertility. World J. Agric. Sci. 2015;6:696-699.

10. Suman J, Dwivedi BS, Dwivedi AK, Pandey SK. Interaction effect of phosphorus and sulphur on yield and quality of Soybean in a vertisol Int.J. Curr. Microbiol.App. Sci. 2018;7(3):152-158.
11. Chen K, Arora R. Priming memory invokes seed stress-tolerance. Environ Exp Bot. 2012;94:33-45.
12. Vyas MD, Jain AK, Tiwari RJ. Long-term effect of micronutrients and FYM on yield of and nutrient uptake by soybean on a typic chromustert. Indian Soc. Soil Sci. 2010;51(1):45-48.
13. Goiba PK, Durgude AG, Pharande AL, Kadlag AD. Effect on uptake of iron and zinc in soybean as influenced by seed priming with iron and zincin soybean (*Glycine max*). International Journal of Chemical Studies. 2018a;6(2):434-436.
14. Barangule SB, Patil VD, Chalak AL, Dhamak AL. Pawar GS. Effect of nutrient seed dressing on nutrient concentration and nutrient uptake of kharif sorghum (Sorghum bicolorL. Monech). International Journal of Chemical Studies. 2018; 6(5):1470-1473.
15. Ravi S, Channal HT, Hebsur NS, Patil BN, Dharmatti PR. Effect of sulphur, zinc and iron nutrition on growth, yield, nutrient uptake and quality of Safflower (*Carthamustinctorius* L.). Karnataka J. Agric. Sci. 2008l21(3):382-385.
16. Dubey SD, Husain K, Srivastava RL.Response of phosphorus and sulphur in linseed (*Linum usitatissimum* L) Advances in plant science. 2000;13(2): 535-538.
17. Sale RB, Nazirkar RB, Ritu S Thakare and Nilam B Kondvilkar. Effect of foliar spray of zinc, iron and seed priming with molybdenum on growth and yield attributes and quality of soybean in the rainfed condition of Vertisol. International Journal of Chemical Studies 2018;6(1):828-831.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/121199